RESOURCES IN PLASMA SPECTROSCOPY

- CURRENT TECHNOLOGIES @ IAEA

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International Atomic Energy Agency (IAEA)

http://www.iaea.org/

- Founded in 29 July 1957
- Vienna, Austria
- 171 Member States (5 Feb 2019)
- 6 departments
- 2500 workers
- Regular budget €364M

- 144 countries receiving support through technical cooperation
- assists its Member States, in the context of social and economic goals, in planning for and using nuclear science and technology for various peaceful purposes, including the generation of electricity, and facilitates the transfer of such technology and knowledge in a sustainable manner to developing Member States;
- 500 000 visitors/month to iaea.org

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IAEA Atomic and Molecular Data Unit

Fusion research requires huge amounts of material data – AM/PSI data

- IAEA A+M Unit formed in 1977
  - Under the supervision of International Fusion Research Council (IFRC) subcommittee on atomic, molecular and plasma-surface interaction data.
  - A+M Unit part of Nuclear Data Section (https://www-nds.iaea.org/)
- Review progress and achievements of *Atomic, molecular and plasma-surface interaction (A+M/PSI) data for Fusion programme*
- Stimulate international cooperation in measurement, compilation and evaluation of A+M / PSI data for fusion

Unit Head: Christian Hill

Atomic Physicist: Kalle Heinola

Scientific Data Manager: Ludmila Marian

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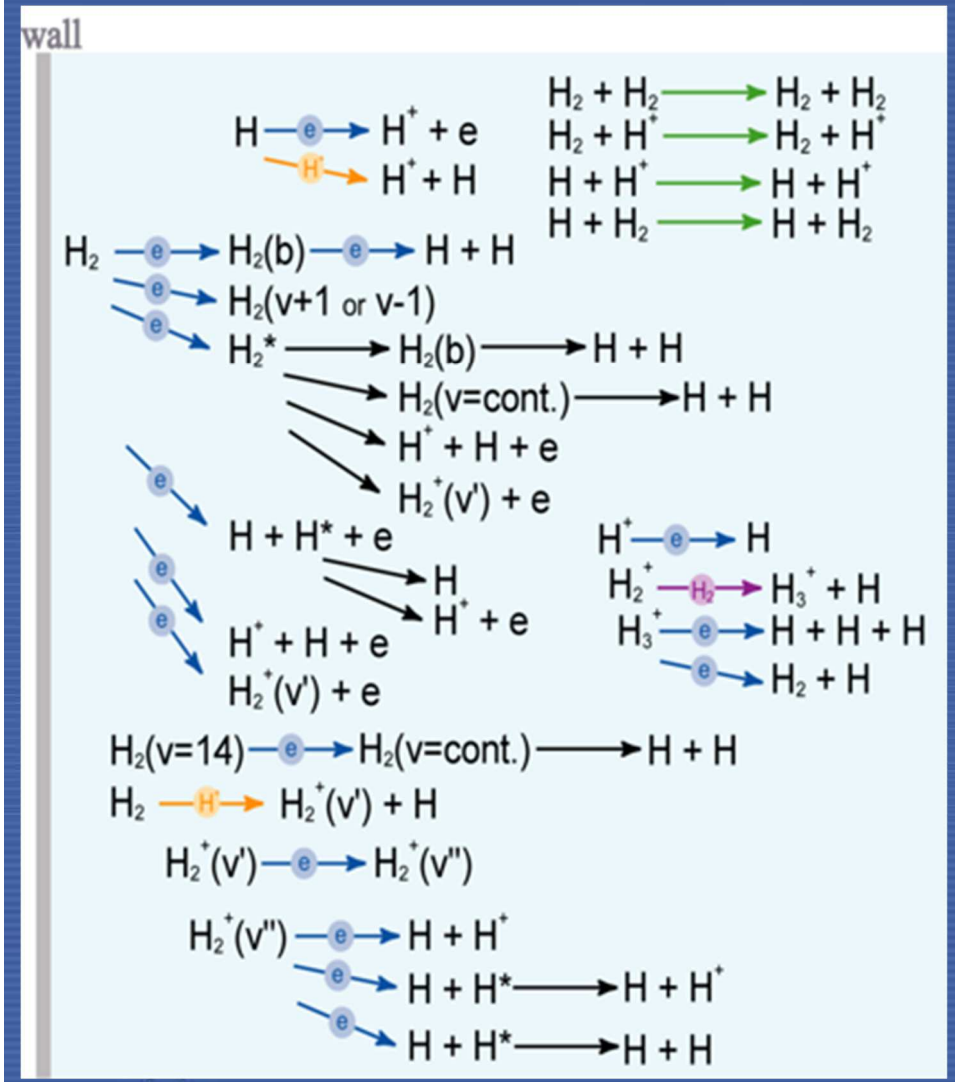
A+M Data Unit priorities

Example of atomic and molecular processes required for Hydrogen

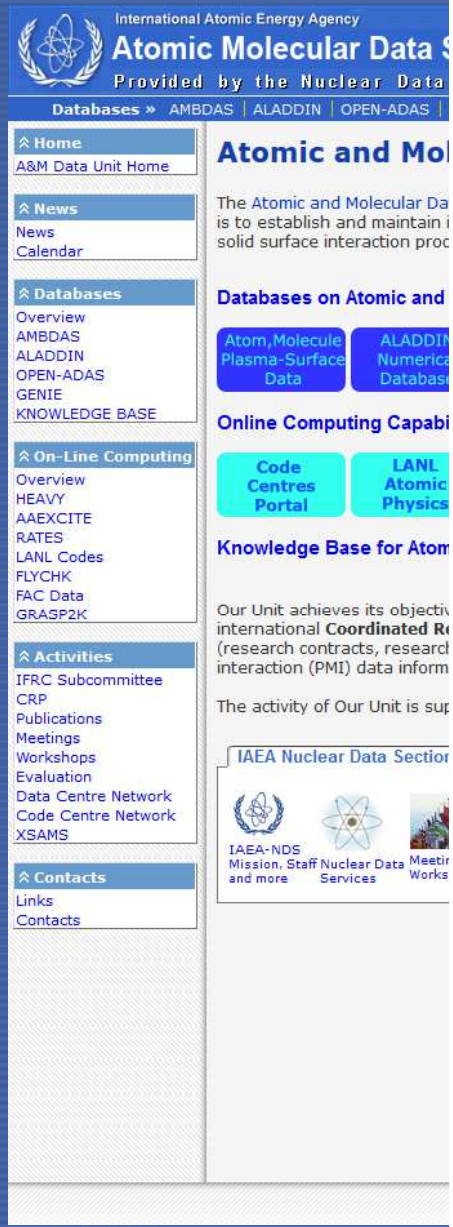


- Atomic data
  D, T, He, Be, C, O, N, Ne, W, Xe, Kr, Ar
  Ti, Cr, Fe, Cl, Mo, V, Cu, Li, Sn, B, S, Cs, Hf, Ta
  Excitation, Ionization, Recombination
  Charge exchange
- Molecular data
  H_2, H_2^*, H_2^+, H_3^+, H_2O, CO, CO_2, CH_4, CH, C_2, Be hydrides, oxides and nitrides, N_2, and other hydrocarbons and radicals including hydrogen isotopic variants
  B, LiH, SnH_4, Cs hydrides and oxides
  Excitation, Ionization, Recombination, Dissociation
- Plasma-Surface Interaction data
  D, T, He, Be, C, O, N, Ne, W, Xe, Ar, Be-W, Be-O, W-O, Be-C, C-W, Be-C-W
  Sputtering, Reflection, Penetration, Adsorption, Gettering, Diffusivity

A+M Data Unit

interim url
https://www-amdis.org/

https://www-amd



AMD Unit | About Activities Databases Online Computing

About | Links | News | IFRC A+M Subcommittee | Contact

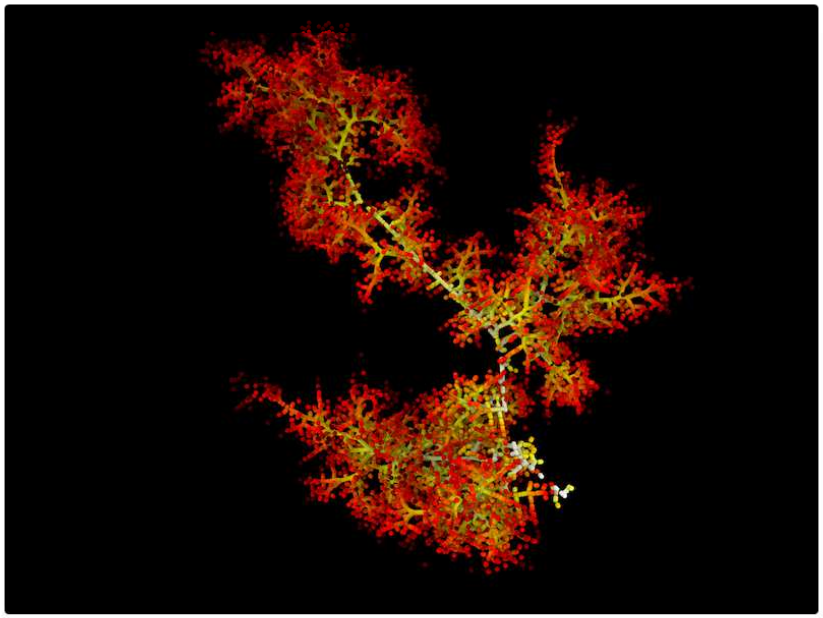
The Atomic and Molecular Data Unit establishes and maintains numerical databases of fundamental data for fusion energy research, and facilitates collaborative international research in the production and evaluation of such data. Read more.

Recent and Upcoming Meetings

6 – 10 May 2019	ICTP Workshop 2019: Atomic and Molecular Spectroscopy in Plasmas
6 – 7 June 2019	Consultancy Meeting on Evaluation of Fundamental Data on Beryllium-containing Species for Edge Plasma Modelling

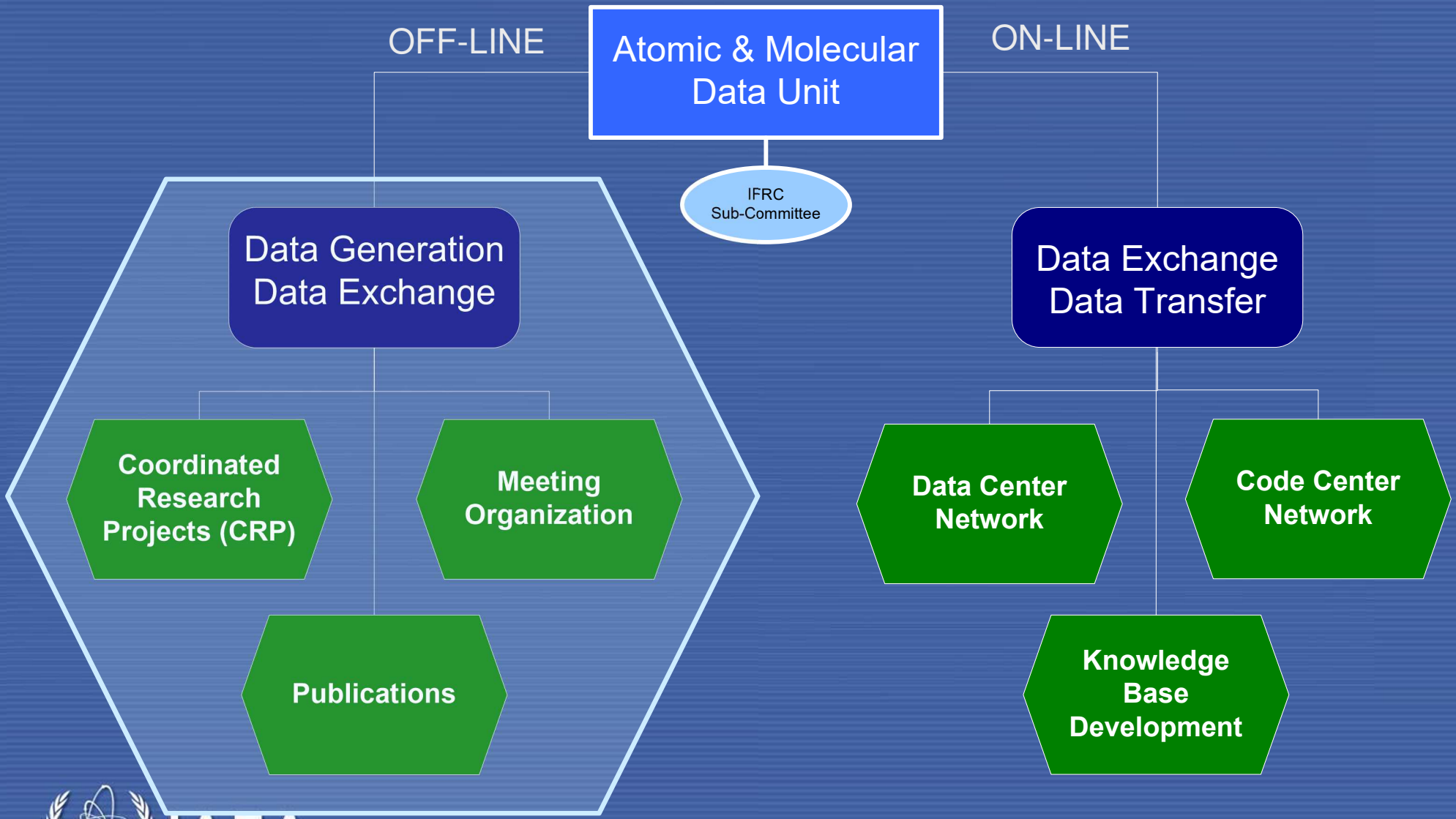
Quick Links

- Our CRPs
  - Hydrogen Permeation (planned)
  - Vapour Shielding
  - Neutral Beams
  - Steel Surfaces
  - Irradiated Tungsten
- Our Meetings
- Global Network for the Atomic and Molecular Physics of Plasmas (GNAMPP)
- Conferences and workshops in atomic and molecular physics



An illustration of the simulated collisional cascade in tungsten caused by the impact of a 200 keV neutron.

Overview of A+M Data Unit Activities



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Coordinated Research Projects (CRP)

Data Generation and Exchange

CRP: Coordinated Research Project

- Main mechanism by which the AMD Unit encourages new research
- Unique opportunity for comprehensive and synergistic collaboration

Joint research on A+M and PSI data for fusion

- Representatives from 10 to 15 institutes worldwide
- Duration 3 – 4 years; 3 Research Coordination Meetings (RCM)

Objectives: to define and coordinate international research on

- Generation, compilation, and evaluation of data
- Establishment of databases
- Development of new techniques

Outputs:

- Publications, Meeting presentations and reports
- Final reports historically “Atomic and Plasma-material Interaction Data for Fusion (APID)”; more recently in journals (JPCF, Atoms, Nuclear Fusion)
- Data and results in ALADDIN numerical Database and Knowledge Base

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Coordinated Research Projects (CRP)

Data Generation and Exchange

Up-to-date list on interim url https://www-amdis.org/CRP/ (https://www-amdis.org/ → Activities → CRPs)

AMD Unit | About | Activities | Databases | Online Computing

CRPs | Data Centres Network | Code Centres Network | GNAMPP | Meetings | Workshops

Coordinated Research Projects

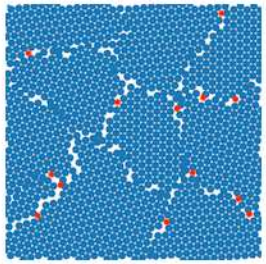
Coordinated Research Projects (CRPs) bring together scientists representing institutes in Member States to collaborate on a focussed research topic that is of shared interest and is important to the mission of the Agency. A CRP is normally approved for a period of 3–5 years and involves 8–15 laboratories, research teams or institutions. Most CRPs involve three Research Coordination Meetings (RCMs) where participants are brought together. The IAEA supports the cost of the RCMs, but only very limited funds are available for direct research support, and this only for participants from developing countries.

In the case of CRPs organized by the AMD Unit, the goals of the CRP may include the establishment of a particular database, data generation, compilation and assessment for specific types of atomic and molecular collision processes. A CRP generally results in a significant amount of new data on collision processes or structural properties of elements or materials relevant to fusion energy research. In addition a CRP may provide detailed critical assessments of the existing data and selection of sets of data that are recommended as the best available at the time of the assessment. The CRP results of adequate accuracy and completeness are stored in the ALADDIN database and published in the IAEA publication series Atomic and Plasma-Material Interaction Data for Fusion (APID).

During the last 10 years the IAEA AMD Unit has been running about an average of about three active CRPs at a time.

Planned CRPs

Hydrogen Permeation in Nuclear Materials



This proposed CRP is at an early stage of planning. It will seek to enhance the knowledge base and reduce uncertainties in data concerning the migration of hydrogen in materials of relevance to nuclear fusion reactors. Of primary interest are candidate divertor and first-wall materials such as tungsten and various types of reduced-activation ferritic/martensitic steel (RAFM), but various copper alloys, as well as materials used in the nuclear fission industry may also be in scope.

Full details

Active CRPs

Atomic Data for Vapour Shielding in Fusion Devices

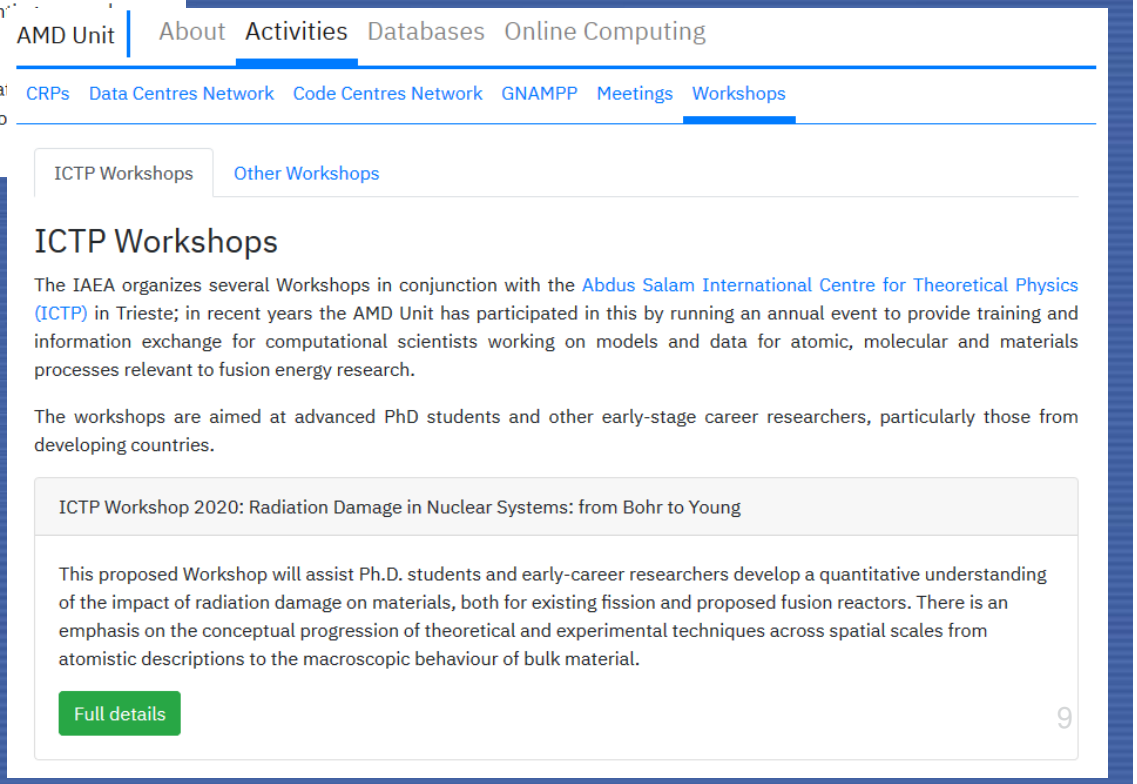
Meetings, Workshops

Data Generation and Exchange

https://www-amdis.org/meetings/

https://www-amdis.org/ → Activities → Meetings → Workshops

https://www-amdis.org/workshops/



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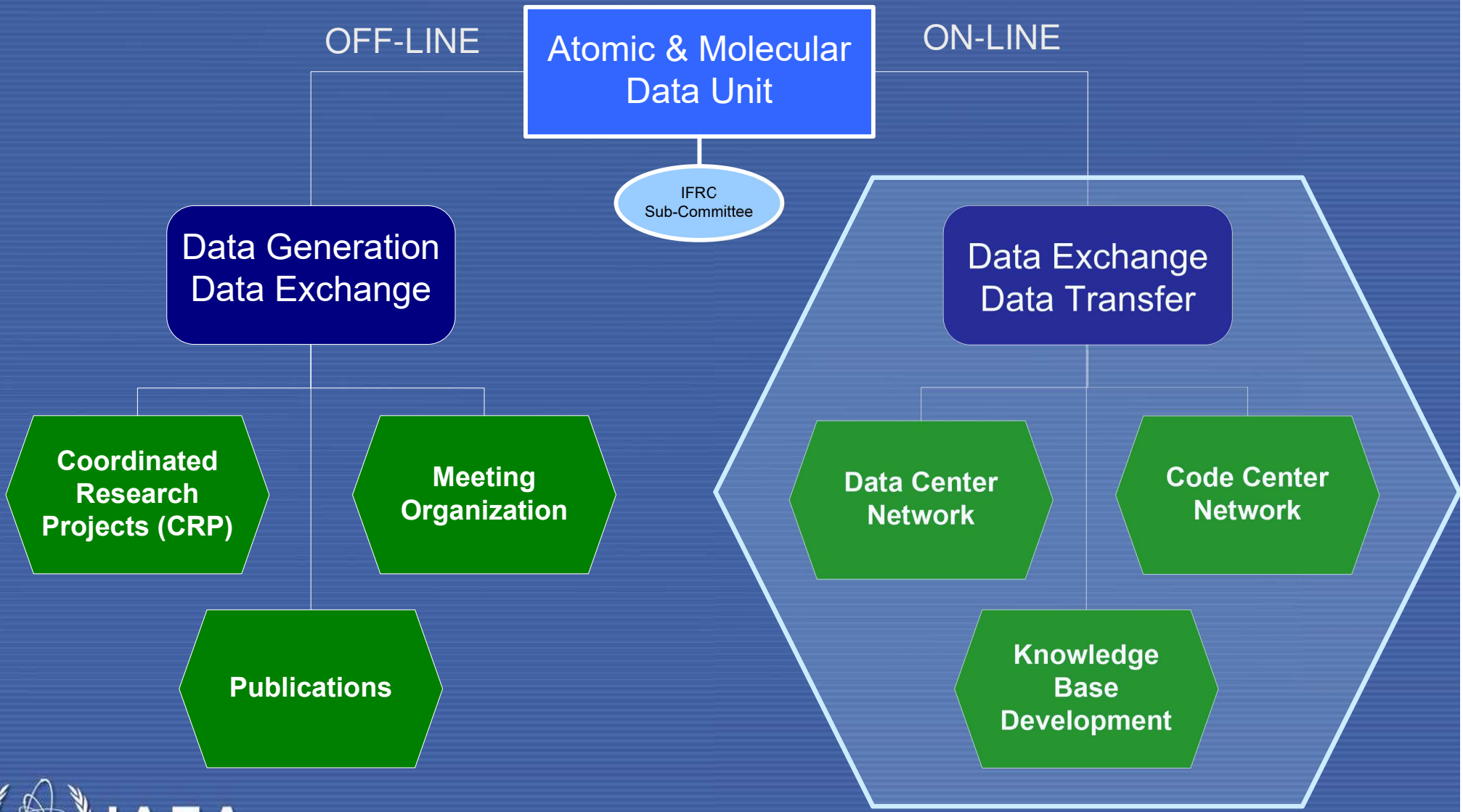
Overview of A+M Data Unit Activities



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Data Centre Network (DCN) activities

Data Exchange and Transfer

Domain : A+M and PSI data as well as bulk material properties (plasma-material interaction - PMI) data for fusion and other applications. (A+M/PSI/PMI)

Established Program: Collection, Dissemination, Critical assessment (evaluation) and generation of A+M, PSI, and PMI data

- ALADDIN: Numerical Database (A+M/PSI)
- AMBDAS: Bibliographic Database
- CASCADESDB: Irradiations damage Database (PMI)
- CLERVAL: Events and Institutes Database

- OPEN-ADAS: Numerical Database
- GENIE: Search Engine on Numerical Databases

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Data Centre Network (DCN) activities

Data Exchange and Transfer

https://www-amdis.org/databases/

AMD Unit | About | Activities | Databases | Online Computing

Databases

The Atomic and Molecular Data Unit manages several numerical and bibliographic databases for fusion and other plasma science research:

- AMBDAS: Atomic and Molecular Bibliographic Data System
- ALADDIN: Numerical database of collisional cross sections and plasma-material interaction data
- CascadesDB: Database of Molecular Dynamics simulations of collision cascades in materials of relevant to fusion research
- Clerval: Database of institutions, people and events related to atomic and molecular data

Further resources

ORNL "Red Book" Series: Atomic Data for Fusion

The Controlled Fusion Atomic Data Center (CFADC) at Oak Ridge National Laboratory (ORNL) produced a series of printed compilations of atomic data for fusion applications known as the "Red Books". Since its closure, scanned versions of some of these reports have been difficult to find – they are provided for download below as a convenience to the fusion data community.

- Volume 1: "Collisions of H, H_2, He and Li Atoms and Ions with Atoms and Molecules" (pdf: 10.8 MB), C. F. Barnett (ed.), ORNL-6086 (1990)
- Volume 2: "Collisions of Electrons with Atoms and Molecules", J. W. Gallagher (ed.), ORNL-6087, 2nd ed., (1994)
- Volume 3: "Atomic Data for Fusion: Particle Interactions with Surfaces" (pdf: 11.4 MB), E. W. Thomas (ed.), ORNL-6088 (1985)

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Data Centre Network (DCN) activities

Data Exchange and Transfer

https://www-amdis.org/databases/

ALADDIN: Numerical database

- Atomic and Molecular collisional database
  - Heavy particle collisions / electron collisions / photon collisions
  - search by reactants, products, process, data types, author, publication
- Plasma-surface interaction database
  - Reflection / sputtering / radiation enhanced sublimation / penetration
  - Search by projectile, surface, chemical component, data type, author, publication
- Data developed through CRPs, and meetings recommended by IFRC

Data Centre Network (DCN) activities

Data Exchange and Transfer

https://www-amdis.org/databases/

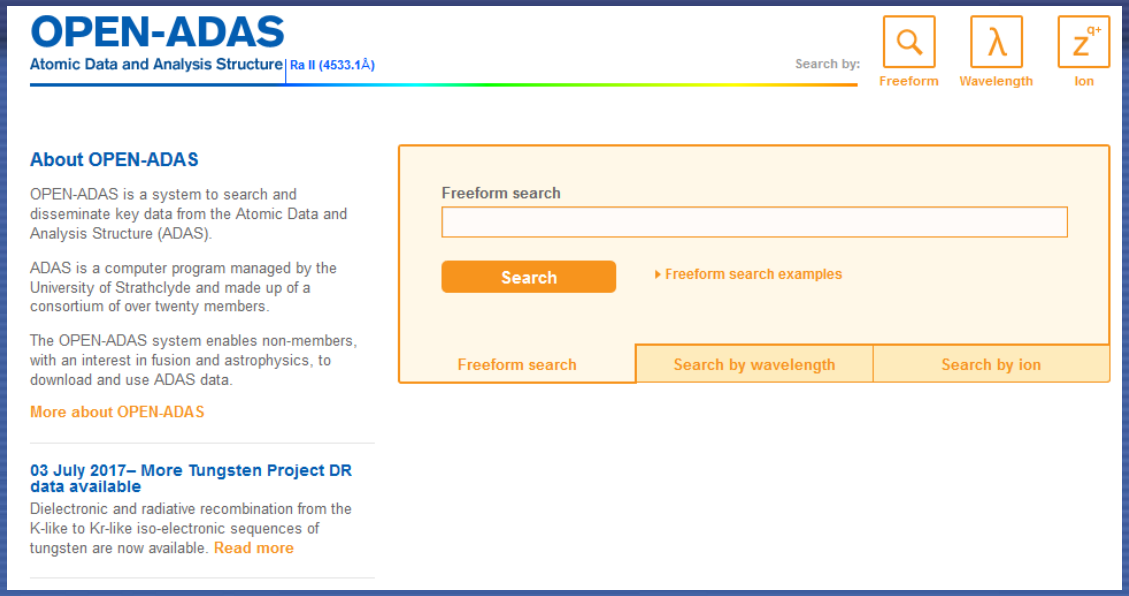
AMBDAS: Bibliographical database

- Data source
  - Spectroscopic data from NIST
  - Collisional data from ORNL
  - Data entries relevant for fusion
- Data search
  - Reactants, processes, authors, keywords, year
  - Results with authors, title, reference and DOI (Digital Object Identifier)

Data Centre Network (DCN) activities

Data Exchange and Transfer

http://open.adas.ac.uk/



- ADAS is an interconnected set of computer codes and data collections for modelling
  - Radiating properties of ions and atoms in plasmas for fusion and astrophysical application
  - Analysis and interpretation of spectral measurements collisional database
- OPEN-ADAS is a free web access to ADAS data
  - A joint development between the ADAS Project and the IAEA to provide access to fundamental and derived atomic data from the ADAS project and its related databases.

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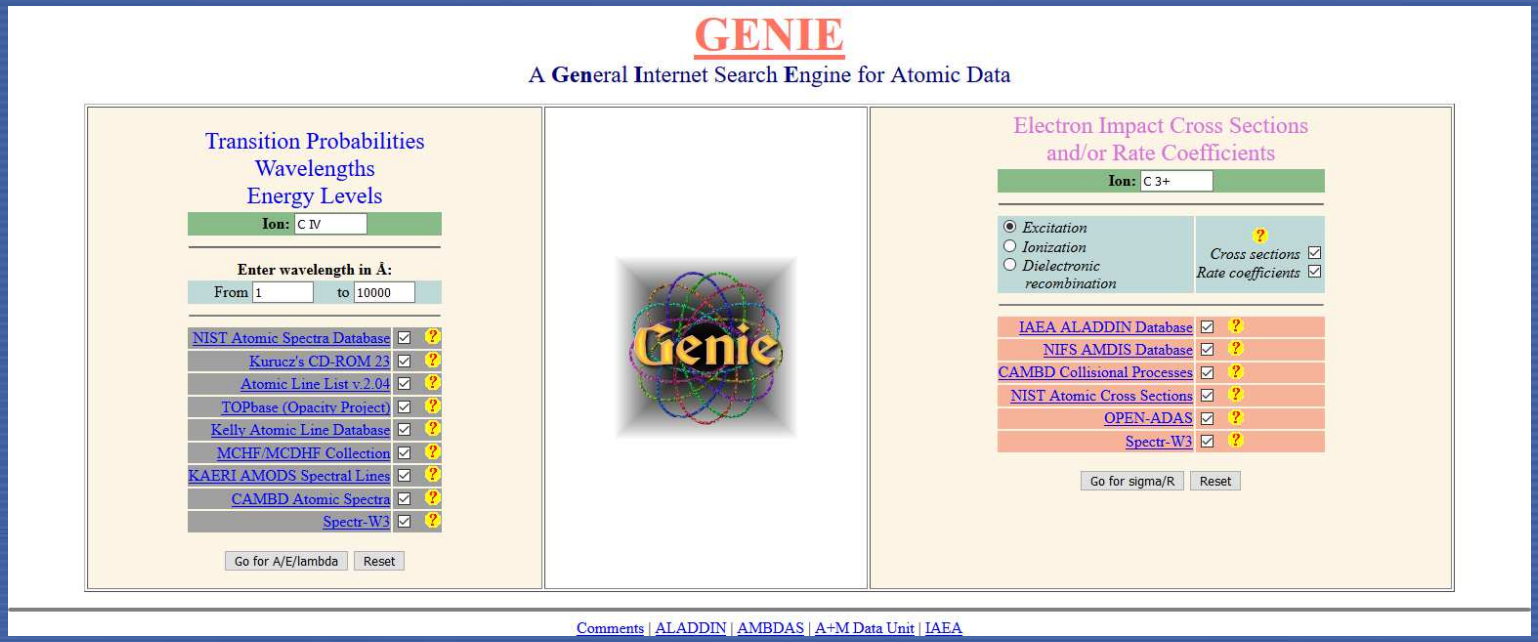
Data Centre Network (DCN) activities

Data Exchange and Transfer

https://www-amdis.iaea.org/GENIE/



Web search engine for atomic data

Radiative properties – search on 8 databases

Collisional databases – search on 4 databases

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Code Centre Network (CCN) activities

Data Exchange and Transfer

CCN: Joint effort to gather and provide access to any information relevant for modellers in fusion plasma science

- Online computing
- Downloadable codes
- Direct contacts with the CCN for any expertise

- Online codes for Heavy Particle Collisions
- Online codes for Average Approximation
- Online codes for Rate Coefficients
- Results and link to Los Alamos atomic physics codes
- Results and link to FLYCHK code

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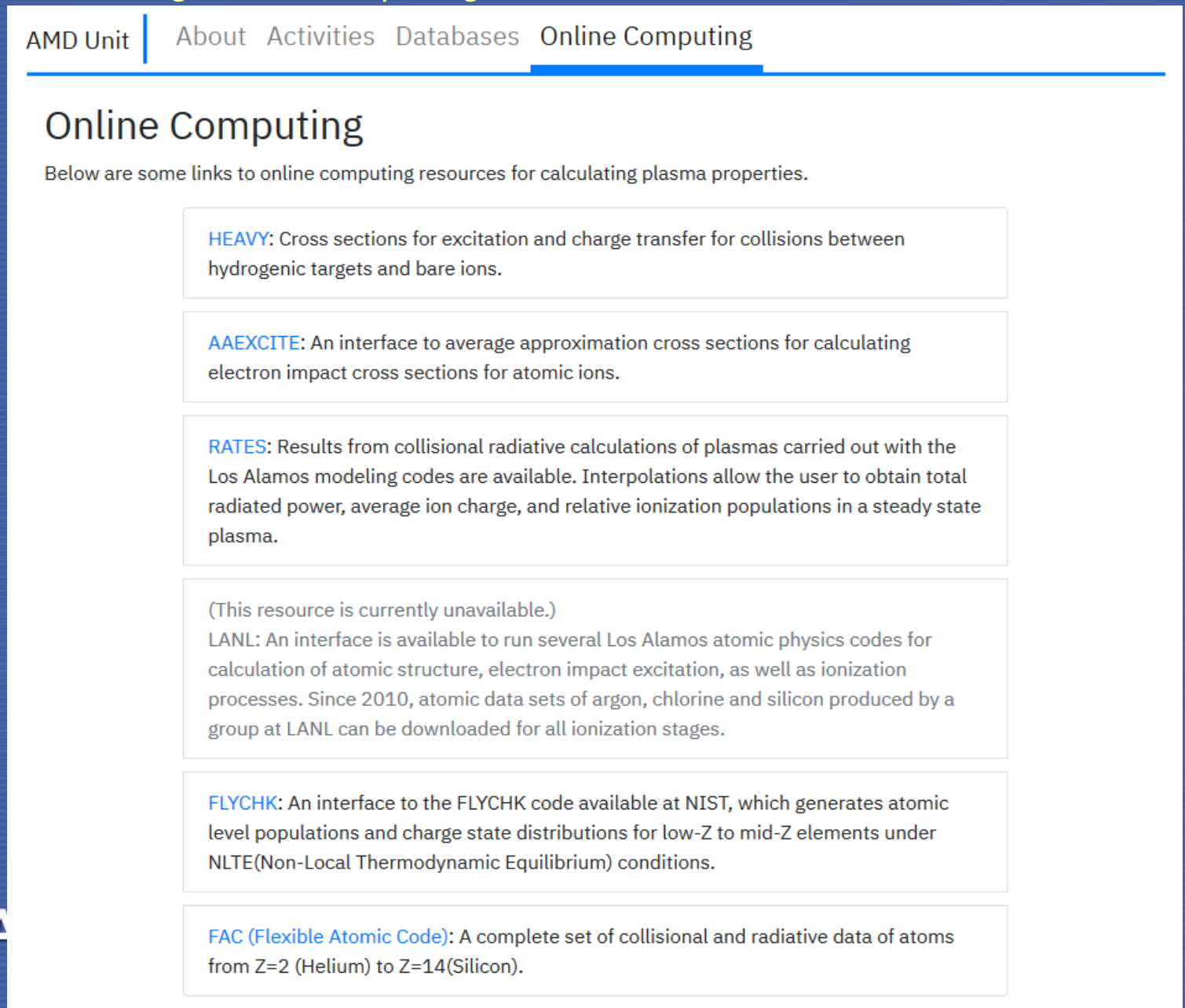
Code Centre Network (CCN) activities

Data Exchange and Transfer

https://www-amdis.org/online-computing/



Knowledge Base and Clerval

Knowledge Base organization (https://www-amdis.iaea.org/w)

- Use of Wiki pages – AMD Unit in a coordinator role
- Community ownership: voluntary content contribution & peer review
- Central location – direct data storage or link to data storage
- Provide information on data and their applications in a context
- Closer community network → Foster collaboration on a focused topic

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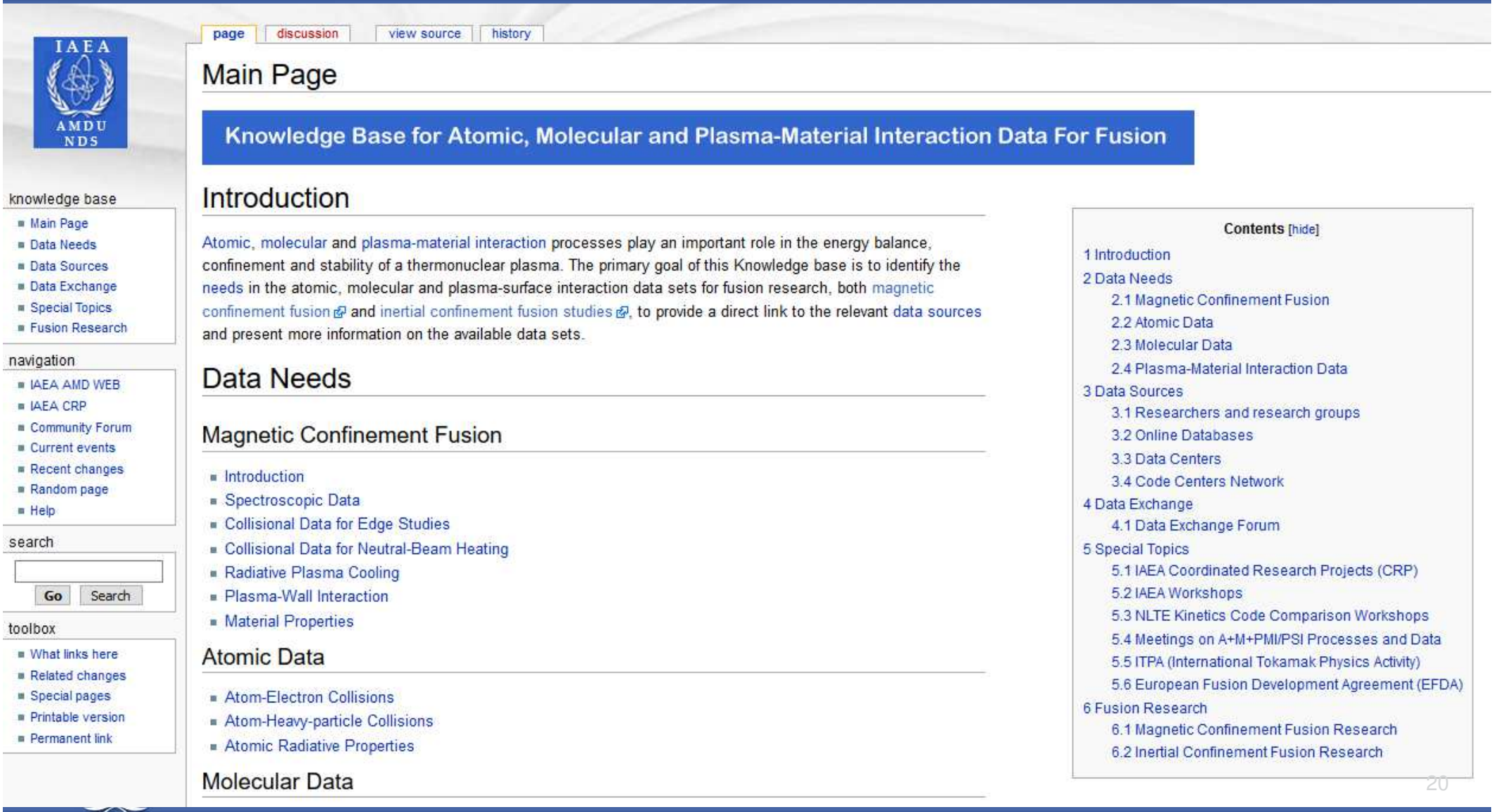

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Clerval (https://www-amdis.org/clerval/)

- Database of
  - events
  - institutes

  relevance to the use, calculation and measurement of A+M/PSI/PMI data in nuclear fusion research

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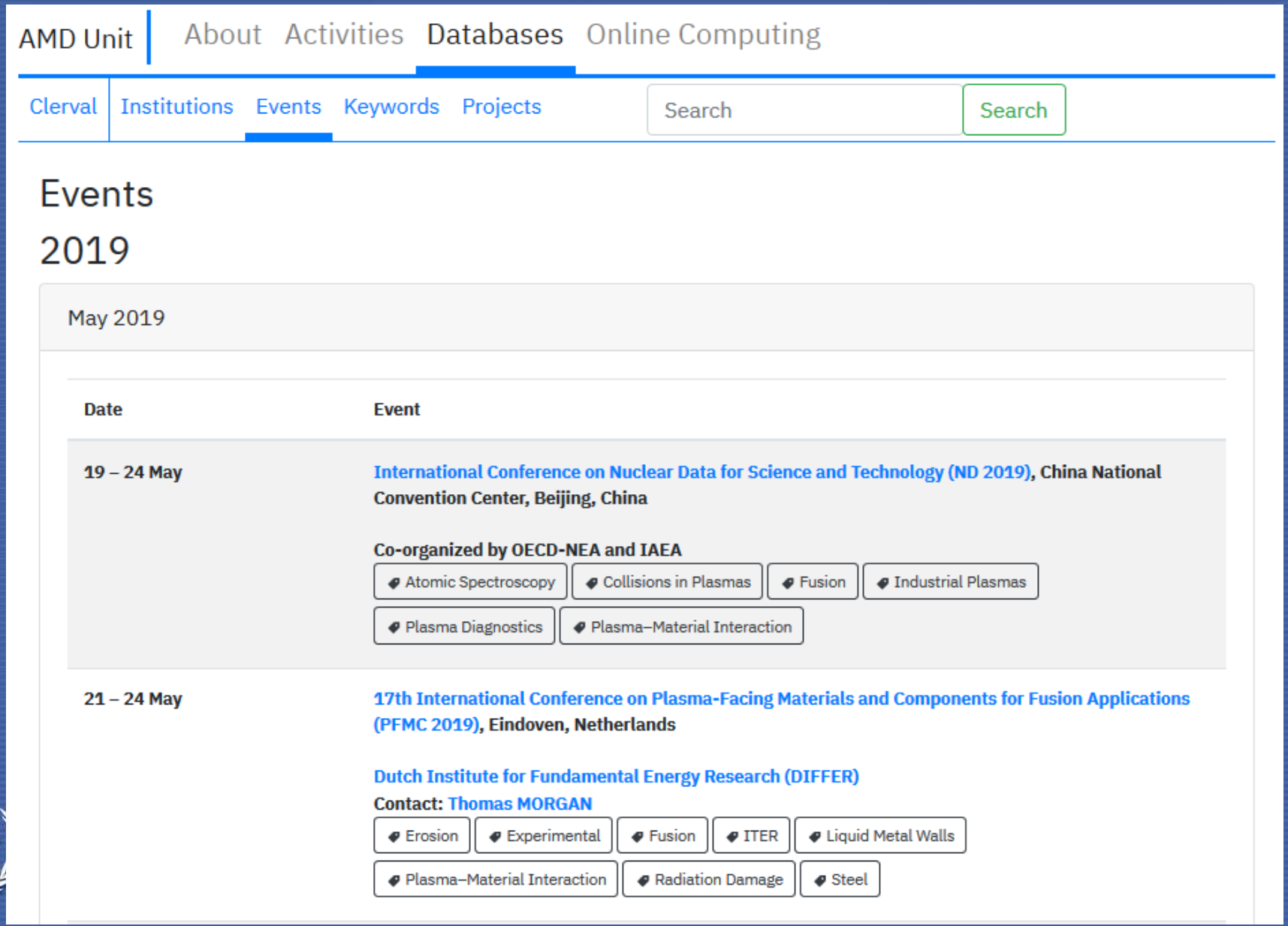
Knowledge Base and Clerval

Clerval (https://www-amdis.org/clerval/)



GNAMPP

Researcher network

Global Network for the Atomic and Molecular Physics of Plasmas
GNAMPP

https://www-amdis.org/GNAMPP

Purpose

- Consortium of research groups working in the area of *fundamental A+M* physics relevant to plasma processes
- Focus on promoting *collaboration and communication* between experimentalists and theoriticians to improve the quality and completeness of data used in modelling and interpreting fusion plasmas

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GNAMPP

Researcher network

Global Network for the Atomic and Molecular Physics of Plasmas
GNAMPP

https://www-amdis.org/GNAMPP

Functions

- Data evaluation
- Data dissemination
- Benchmarking calculations against experiments
- Find collaborators
- Setting priorities for data needs in nuclear fusion research
- Mailing list for communicating events, funding, and job opportunities, new data
- Description of research interests with recent publications

GNAMPP

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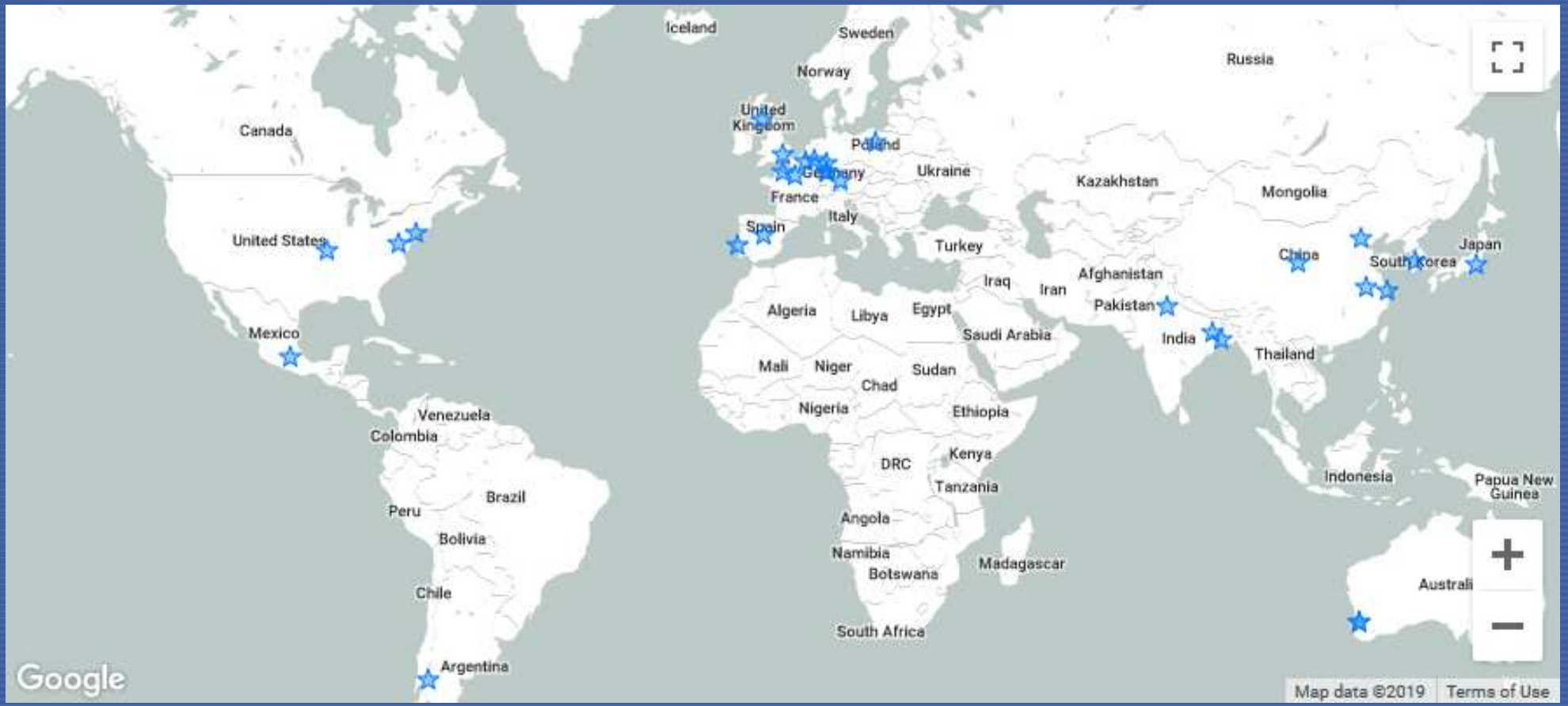

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